For life science research only.
Not for use in diagnostic procedures.

Cytotoxicity Detection Kit (LDH)

Version: 12
Content Version: November 2020

A nonradioactive alternative to the [^{3}H]-thymidine- and [^{51}Cr]-release assays.
Colorimetric assay for the quantification of cell death and cell lysis, based on the measurement of lactate dehydrogenase (LDH) activity released from the cytosol of damaged cells into the supernatant.

Cat. No. 11 644 793 001 1 kit
2,000 tests

Store the kit at −15 to −25°C.

1. General Information

1.1. Contents

Vial / Bottle	Cap	Label	Function / Description	Content
1	blue	Cytotoxicity Detection Kit, Catalyst	▪ Lyophilized, stabilized ▪ Catalyst for reaction mix. ▪ Diaphorase/NAD^+ mixture.	5 bottles
2	red	Cytotoxicity Detection Kit, Dye solution	▪ Ready-to-use solution. ▪ Contains iodotetrazolium chloride (INT) and sodium lactate. ▪ Dyes the reaction mix.	5 bottles, 45 ml each

1.2. Storage and Stability

Storage Conditions (Product)

The kit is shipped on dry ice.
When stored at −15 to −25°C, the kit is stable through the expiration date printed on the label.

Vial / Bottle	Cap	Label	Storage
1	blue	Catalyst	Store at −15 to −25°C.
2	red	Dye solution	

1.3. Additional Equipment and Reagent required

Standard laboratory equipment

- +37°C incubator
- Centrifuge with rotor for microplates
- ELISA reader for microplates, with 490 to 492 nm filter
  If a reference wavelength will be subtracted, use a filter >600 nm.
- Microscope
- Hemocytometer
- Multichannel pipettor (100 µl)
- Sterile pipette tips
- 96-well microplates:
  – For the measurement of cell-mediated lysis and for the analysis of cytotoxic compounds, use sterile, cell-culture quality with round or V-bottom for suspension cells, or with flat bottom for adherent cells.
  – For color development in all assays, use optically clear, flat-bottomed microplates.

Standard laboratory reagents

- Double-distilled water
- Assay medium, such as medium containing 1% serum or 1% bovine serum albumin.
  – Both human and animal sera contain various amounts of LDH which may increase background absorbance in the assay. Therefore, to increase the sensitivity, perform the assay in the presence of low serum concentrations, such as 1% or replace serum with 1% bovine serum albumin (BSA) (w/v).
- Triton X-100 solution* (2% Triton X-100 in assay medium)
  – The maximum amount of releasable LDH enzyme activity is determined by lysing the cells with Triton X-100 (final concentration: 1% Triton X-100). At this concentration, Triton X-100 does not affect the LDH activity.
- HCl stop solution (1 N)
  The reaction product can be measured without addition of a stop solution. Alternatively, the enzyme reaction can be stopped by the addition of 50 µl/well 1N HCl (final concentration: 0.2 N HCl).

For LDH standard preparation

- LDH standard solution, such as 0.05 U LDH/ml, see section **Controls.**
  If the released LDH activity is calculated in U/ml instead of percent relative cytotoxicity or absorbance, use an appropriate LDH preparation as standard.

⚠ ***Assay medium, lysing and stopping solutions, as well as LDH standard are not included in the kit; all other reagents necessary to perform 2,000 tests are included.***

1.4. Application

The Cytotoxicity Detection Kit is a precise, fast, and simple colorimetric assay for quantitating cytotoxicity and cytolysis by measuring LDH activity released from damaged cells. Therefore, the kit can be used in many different *in vitro* cell systems when damage to the plasma membrane occurs.

- Determination of the cytotoxic potential of compounds in environmental and medical research, and in the food, cosmetic, and pharmaceutical industries.
- Determination of mediator-induced cytolysis.
- Detection and quantification of cell-mediated cytotoxicity induced by cytotoxic T-lymphocytes (CTL), natural killer (NK) cells, lymphokine activated killer (LAK) cells, or monocytes.
  The LDH release assay and the [^{51}Cr] release assay show good correlation when used to monitor cell-mediated cytotoxicity in a variety of murine and human effector-target cell systems, including NK cells, CTL, and macrophages.
- Measurement of antibody-dependent cellular cytotoxicity (ADCC) and complement-mediated cytolysis.
- Determination of cell death in bioreactors.
  Experiments have shown that measurement of the release of cytoplasmic LDH enzyme activity to the culture medium can provide a precise evaluation of cell death during fermentation in bioreactors.
- The assay can also be used to determine the total numbers of cells present at the end of a proliferation assay.

1.5. Preparation Time

Assay Time

0.5 to 1 hour, including harvesting of the supernatants and substrate reaction.

2. How to Use this Product

2.1. Before you Begin

Sample Materials

The Cytotoxicity Detection Kit (LDH) is used with cell-free supernatants obtained from cells cultured in 96-well microplates or batch cultures. The assay reagent is not harmful to the cells and can be added directly to the cell culture plate. Alternatively, when the samples are not tested directly, remove the cells from the culture medium prior to the determination of LDH activity by centrifugation at approximately 250 × *g*.
⚠ ***Store the cell-free culture supernatant at +2 to +8°C for several days without loss of LDH activity.***

Control Reactions

To calculate percent cytotoxicity, use the following three controls in each experimental setup.

Background control

Determines the LDH activity contained in the assay medium.
⚠ ***The absorbance value obtained in this control must be subtracted from all other values.***

Low control

Determines the LDH activity released from the untreated normal cells (= spontaneous LDH release).

High control

Determines the maximum releasable LDH activity in the cells (= maximum LDH release).

The following two controls are facultative:

Substance control I

Determines the LDH activity contained in the test substance. If cell-mediated cytotoxicity is measured, this control provides information about the LDH activity released from the effector cells (= effector cell control, see **Figure 5, section Protocols**).

Substance control II

Determines whether the test substance itself interferes with LDH activity.
To perform this control:

1. To each control sample (assayed in triplicate) in an optically clear, 96-well, flat-bottom microplate, add 50 µl assay medium containing the test substance.
2. Add 50 µl/well LDH standard solution (0.05 U/ml).
3. Add 100 µl/well Reaction mixture and measure absorbance using an ELISA reader as described in the Protocols below. This is related to the procedure used in section, **Determination of the optimal cell concentration for the assay**, and the other assays in the protocol section.
4. Compare the absorbance values in these controls with absorbance values obtained in separate (triplicate) LDH control samples that contain only 50 µl/well assay medium, 50 µl/well LDH standard solution (0.05 U/ml), and 100 µl/well Reaction mixture.

Overview of the controls

⚠ ***The background, low, and high controls must be determined in each experimental setup.***

Contents of the Well	Background Control [µl]	Low Control [µl]	High Control [µl]	Substance Control 1 [µl]	Substance Control II [µl]	Experimental Sample [µl]
Cell-free culture medium	200	100	–	100	–	–
Cells	–	100	100	–	–	100
Triton X-100 solution (2% in assay medium)	–	–	100	–	–	–
Test substance or effector cells diluted in culture medium	–	–	–	100	50	100
LDH standard solution	–	–	–	–	50	–

Calculation with the controls

To determine the percentage cytotoxicity, calculate the average absorbance values of the triplicate samples and controls, subtract the background from each, then substitute the resulting values in the following equation:

$$\text{Cytotoxicity (\%)} = \frac{\text{exp. value - low control}}{\text{high control - low control}} \times 100$$

Fig. 1: Percent cytotoxicity formula.
To determine the percentage cell-mediated cytotoxicity, calculate the average absorbance of the triplicate samples and controls, subtract the background from each, then substitute the resulting values in the following equation:

$$\text{Cytotoxicity (\%)} = \frac{\text{(effector - target cell mix - effector cell control) - low control}}{\text{high control - low control}} \times 100$$

Fig. 2: Percent cell-mediated cytotoxicity formula.

General Considerations

Potential sources of test interference

- Inherent LDH activity may be found in serum or test substances, see section **Controls**.
- In cell-mediated cytotoxicity assays, the amount of LDH released from damaged effector cells may influence the assay results, see sections **Controls** and **Measurement of cell-mediated cytotoxicity**.
- Substances which inhibit the LDH or diaphorase enzyme activity influence the assay. Include appropriate controls in the assay, see section **Controls**.
- Pyruvate is an inhibitor of the LDH reaction and is contained in some culture media, such as some formulations of DMEM, Ham's F12, or Iscove's.

Safety Information

For customers in the European Economic Area

Contains SVHC: octyl/nonylphenol ethoxylates. For use in research and under controlled conditions only – acc. to Art. 56.3 and 3.23 REACH Regulation.

Laboratory procedures

- Handle all samples as if potentially infectious, using safe laboratory procedures. As the sensitivity and titer of potential pathogens in the sample material varies, the operator must optimize pathogen inactivation by the Lysis/Binding Buffer or take appropriate measures, according to local safety regulations.
- Do not eat, drink, or smoke in the laboratory work area.
- Do not pipette by mouth.
- Wear protective disposable gloves, laboratory coats, and eye protection, when handling samples and kit reagents.
- Wash hands thoroughly after handling samples and reagents.

Waste handling

- Discard unused reagents and waste in accordance with country, federal, state, and local regulations.
- Safety Data Sheets (SDS) are available online on dialog.roche.com, or upon request from the local Roche office.

Working Solution

Content	Reconstitution/Preparation of Working Solution	Storage and Stability
Catalyst (Bottle 1)	Reconstitute the lyophilizate in 1 ml double-distilled water for 10 minutes; mix thoroughly.	▪ The lyophilizate is stable at +2 to +8°C. ▪ After reconstitution, store 4 weeks at +2 to +8°C.
Dye solution (Bottle 2)	Ready-to-use solution.	Once thawed, store several weeks at +2 to +8°C.
Reaction mixture	▪ For 100 tests, shortly before use, mix 250 µl of reconstituted Bottle 1 with 11.25 ml of Bottle 2. ▪ For 400 tests, shortly before use, add the total volume of Bottle 1 (1 ml) to the total volume of Bottle 2 (45 ml); mix thoroughly.	Always prepare fresh before use; do not store.

2.2. Protocols

Determination of the optimal cell concentration for the assay

Different cell types may contain different amounts of LDH, therefore, determine the optimal cell concentration for a specific cell type in a preliminary experiment (Fig. 3). In general, the optimal cell concentration is the one that produces the greatest difference between the Low and High control; use this concentration for the subsequent assay. For most cell lines, the optimal cell concentration is 0.5 to 2 × 10^4 cells/200 µl assay (= 0.25 to 1 × 10^5 cells/ml).
⚠ ***Perform all test samples in triplicate.***

Protocol for a 96-well microplate

1. Wash cells with assay medium.
   – Adjust cell suspension to a concentration of 2 × 10^6 cells/ml in assay medium.

2. Add 100 µl/well assay medium to each well of an entire 96-well, tissue-culture plate.

3. Use a multichannel pipette to prepare two-fold serial dilutions of the cells across the plate.
   – Prepare 6 wells of each dilution.
   ⚠ ***After dilution, the final volume in each well should be 100 µl. Leave at least 3 wells cell-free to use as a Background control.***
   – For each cell dilution, designate 3 wells as a Low control (= spontaneous LDH release) and 3 wells as a High control (= maximum LDH release).
   – For an overview of the controls, see section, **Controls**.

4. Incubate the cells in an incubator at +37°C, 5% CO_2, and 90% humidity,
   ⚠ ***Use the same incubation time that will be used in the final assay.***

5. Centrifuge the microplate at 250 × *g* for 10 minutes.
   ℹ *Optional step for adherent cells.*

6. Carefully remove 100 µl/well supernatant; do not disturb the cell pellet.
   – Transfer into corresponding wells of an optically clear, 96-well flat-bottom microplate.

7. To determine the LDH activity in these supernatants, add 100 µl freshly prepared Reaction mixture to each well, and incubate for up to 30 minutes at +15 to +25°C.
   ⚠ ***Protect the microplate from light during this incubation period.***

8. Measure the absorbance of the samples at 490 or 492 nm according to the available filters using an ELISA reader.

   ⚠ ***Use a reference wavelength of >600 nm.***

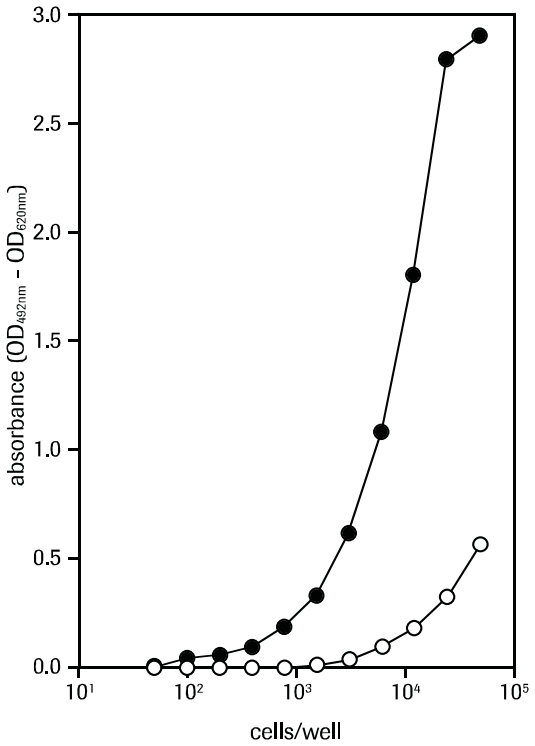

Fig. 3: Determination of the optimal target cell concentration for K-562 cells. K-562 cells were titrated in microplates as described above at cell concentrations indicated in the figure. Culture medium (○) was added for the determination of the spontaneous release of LDH activity and Triton X-100* (●) was added to a final concentration of 1% for the determination of maximal release of LDH activity. Optimal target cell concentration in this experiment is approximately 1×10^4 cells/well.

Measurement of the cytotoxic potential of soluble substances

Protocol for a 96-well microplate

⚠ ***Perform all test samples in triplicate.***

1. Wash the cells in assay medium, then dilute to the concentration determined in section, **Determination of the optimal cell concentration for the assay**.

2. For suspension cells:
   – Titrate test substances, such as mediators, cytolytic or cytotoxic agents in the appropriate assay medium in sterile, 96-well, tissue-culture plates by serial dilutions (final volume of 100 µl/well).
   – Add 100 µl/well cell suspension to the dilutions of the test substances.

3. For adherent cells (Fig. 4):
   – Add 100 µl cell suspension per well in a sterile, 96-well, tissue-culture plate.
   ⚠ ***Do not add cells to wells for Background control and Substance control I.***
   – Incubate the cells overnight in an incubator at +37°C, 5% CO_2, and 90% humidity to allow the cells to adhere tightly.
   – Immediately before use, titrate test substances, such as mediators, cytolytic or cytotoxic agents in the appropriate assay medium in a separate microplate by serial dilutions (final volume of 200 µl/well).
   – Remove the assay medium from the adherent cells to remove LDH activity released from the cells during the overnight incubation step, and add 100 µl fresh assay medium to each well.
   – Transfer 100 µl of the test substance dilutions into corresponding wells containing the adherent cells.

4. For an overview of the different controls, see section, **Controls**.
   – On the same plate, prepare the following controls in triplicate:

Controls	Add to each well
Background control	200 µl assay medium only.
Low control	100 µl cell suspension plus 100 µl assay medium.
High control	100 µl Triton X-100 solution plus 100 µl cells.
Substance control I	100 µl test substance at the maximum concentration used in the experiment plus 100 µl medium.

5. Incubate the cells in an incubator at +37°C, 5% CO_2, and 90% humidity.
   ⚠ ***Depending on the experimental setup, use incubation times of 2 to 24 hours.***

6. For suspension cells, centrifuge the microplate at 250 × *g* for 10 minutes.

7. Carefully remove 100 µl/well supernatant; do not disturb the cell pellet.
   – Transfer into corresponding wells of an optically clear, 96-well, flat-bottom microplate.

8. To determine the LDH activity in these supernatants, add 100 µl freshly prepared Reaction mixture to each well, and incubate for up to 30 minutes at +15 to +25°C.
   ⚠ ***Protect the microplate from light during this incubation period.***

9. Measure the absorbance of the samples at 490 or 492 nm according to the available filters using an ELISA reader.

   ⚠ ***Use a reference wavelength of >600 nm.***

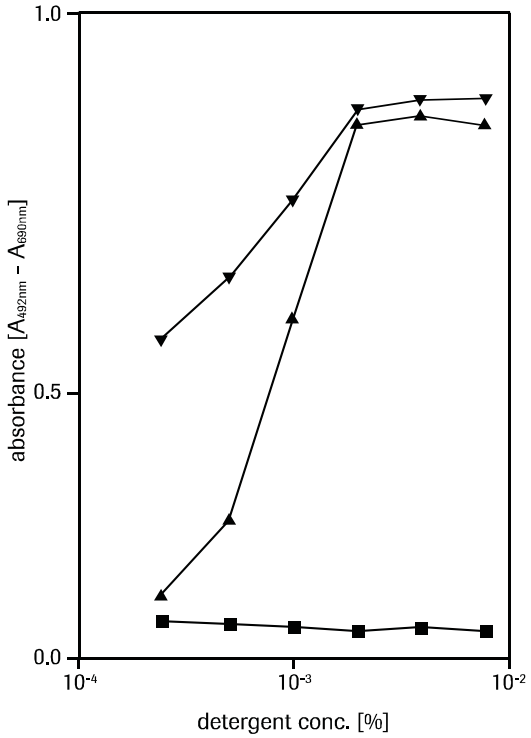

Fig. 4: Measurement of the cytotoxic potential of various detergents, such as Synperonic® F68 (■), Triton X-100* (▲), and Nonidet P40* (▼) were titrated in microplates in culture medium as described in section, **Measurement of the cytotoxic potential of soluble substances** to final concentrations indicated in the figure. Subsequently P815 cells were added to a final concentration of 1 × 10^4cells/well. The cells were incubated for 18 hours and LDH release was determined as described above.

Measurement of cell-mediated cytotoxicity

Sample arrangement on a 96-well microplate

⚠ ***Perform all test samples in triplicate.***

Background Control	Target Cell Low Control	Target Cell High Control	Blank
Effector – target cell mix ratio 1	Effector – target cell mix ratio 7	Effector cell control for mix ratio 1	Effector cell control for mix ratio 7
Effector – target cell mix ratio 2	Effector – target cell mix ratio 8	Effector cell control for mix ratio 2	Effector cell control for mix ratio 8
Effector – target cell mix ratio 3	Effector – target cell mix ratio 9	Effector cell control for mix ratio 3	Effector cell control for mix ratio 9
Effector – target cell mix ratio 4	Effector – target cell mix ratio 10	Effector cell control for mix ratio 4	Effector cell control for mix ratio 10
Effector – target cell mix ratio 5	Effector – target cell mix ratio 11	Effector cell control for mix ratio 5	Effector cell control for mix ratio 11
Effector – target cell mix ratio 6	Effector – target cell mix ratio 12	Effector cell control for mix ratio 6	Effector cell control for mix ratio 12

Protocol for a 96-well microplate

⚠ ***Perform all test samples in triplicate.***

1. Titrate effector cells, such as NK cells, LAK cells, and CTLs into the appropriate assay medium in sterile, 96-well, tissue-culture plates by serial dilutions (final volume of 100 µl/well).

2. Wash the target cells in assay medium; dilute to the concentration determined in the section, **Determination of the optimal cell concentration for the assay**.

3. Add 100 µl/well target cell suspension to the dilutions of effector cells (= effector-target cell mix), see **Sample arrangement on a 96-well microplate**.

4. For the the different controls, see section, **Controls**.
   On the same plate, prepare the following controls in triplicate:

Controls	Add to each well
Background control	200 µl assay medium only.
Low control (= spontaneous LDH release)	100 µl target cells plus 100 µl assay medium.
High control (= maximum LDH release)	100 µl target cells plus 100 µl Triton X-100 solution.
Substance control I (= effector cell control = spontaneous release of LDH by the effector cells)	100 µl assay medium plus 100 µl effector cells.

   ⚠ ***Always determine the spontaneous LDH release for each effector cell concentration used in the assay.***

5. Incubate the cells in an incubator at +37°C, 5% CO_2, and 90% humidity for the appropriate time period.

6. Centrifuge the microplate at 250 × *g* for 10 minutes.

7. Carefully remove 100 µl/well supernatant; do not disturb the cell pellet.
   – Transfer into corresponding wells of an optically clear, 96-well, flat-bottom microplate.

8. To determine the LDH activity in these supernatants, add 100 µl freshly prepared Reaction mixture to each well, and incubate for up to 30 minutes at +15 to +25°C.
   ⚠ ***Protect the microplate from light during this incubation period.***

9. Measure the absorbance of the samples at 490 or 492 nm according to the available filters using an ELISA reader (Fig. 5).

   ⚠ ***Use a reference wavelength of >600 nm.***

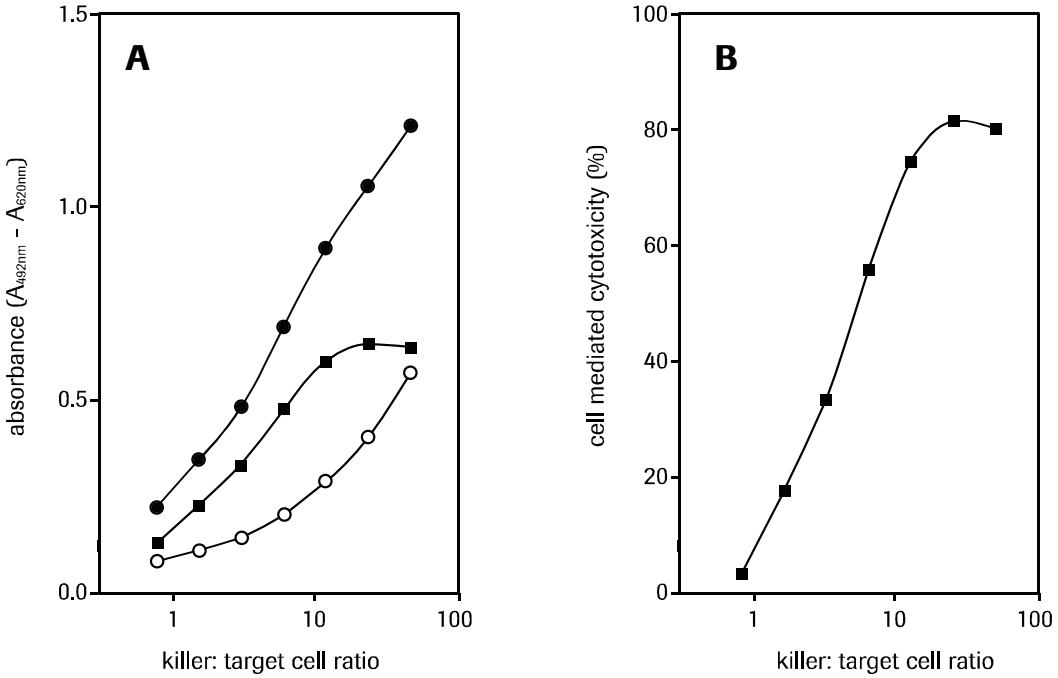

Fig. 5: Determination of the cytolytic activity of allogen-stimulated, cytotoxic T lymphocytes (CTLs). Spleen cells of C57/Bl 6 mice (H-2b) were stimulated *in vitro* with P815 cells (H-2d). Viable CTLs were purified by ficoll density gradient, washed and titrated in the microplate as described in section**, Measurement of cell mediated cytotoxicity**. 1 × 10^4 P815 target cells/well were added to the effector cells. The cells were centrifuged and incubated for 4 hours. 100 µl of culture supernatant was removed and LDH activity determined as described in section, **Measurement of cell mediated cytotoxicity**.
A. Absorbance values. Effector cell control (○), effector-target cell mix (●), effector-target cell mix minus effector cell control (■).
B. Percentage cell-mediated cytotoxicity, calculated as described in section, **Controls**.

Measurement of cell death in eukaryotic cell fermentation

1. Collect 0.5 to 1 ml samples at regular intervals of 12 or 24 hours from cell culture.

2. Spin the samples and carefully remove culture supernatant.
   Collect and store the cell-free supernatants at +2 to +8°C without loss of enzyme activity for several days.

3. Titrate the culture supernatants in the appropriate culture medium by serial dilutions to obtain a final volume of 100 µl/well.

4. Add 100 µl freshly prepared Reaction mixture to each well, and incubate for up to 30 minutes at +15 to +25°C.
   Protect the microplate from light during this incubation period.

5. Measure the absorbance of the samples at 490 or 492 nm according to the available filters using an ELISA reader (Fig. 6).

Use a reference wavelength of >600 nm.

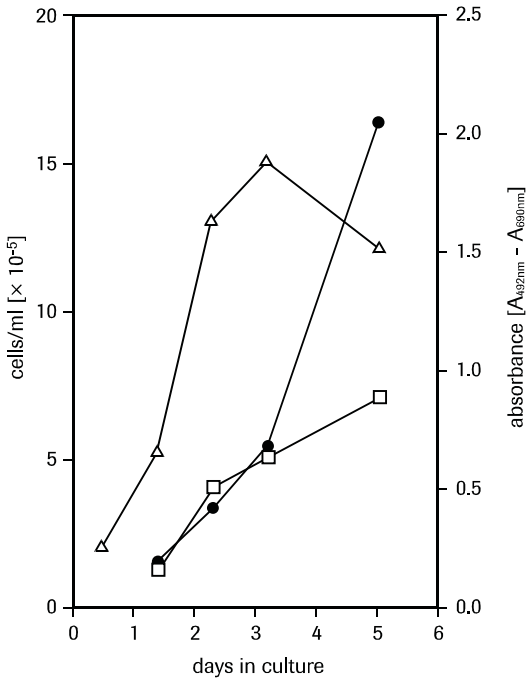

Fig. 6: Correlation of cell death and LDH release in cell culture. Ag 8 cells were seeded at a concentration of 2 × 10^5 cells/ml and incubated at +37°C, 5% CO_2. At days 1, 2, 3, and 5 of culture, aliquots were removed. The amount of viable (△) and dead (●) cells were determined by Trypan Blue exclusion. LDH activity of cell-free culture supernatant (□) was determined as described above.

2.3. Parameters

Sensitivity

Depending on the individual cell type used, 0.2 to 2 × 10^4 cells/well are sufficient for most experiments (Fig. 3).

3. Troubleshooting

Observation	Possible cause	Recommendation
Weak color reaction.	Cell concentration is too low.	Titrate cell concentration.
	Substance or assay medium inhibits LDH activity.	Use Substance control II, see section **Controls**, to test substance and/or assay medium for compounds inhibiting LDH activity.
		Avoid culture media containing pyruvate.
Strong color reaction present in Low controls.	Cell concentration is too high.	Titrate cell concentration.
	Substance or assay medium have LDH activity.	Use Substance control I, see section **Controls**, to test substance and/or assay medium for compounds with LDH activity.
	High spontaneous release due to poor condition of the cells used in the assay.	Check culture conditions; some cell lines do not survive in serum-free media even at short incubation times. Increase serum concentration to approximately 1 to 5%.
Strong color reaction with low absorbance values.	Background values too high.	High background values may lead to low absorbance values if background is automatically subtracted by the plate reader.
	Substance or assay medium have LDH activity.	Use Substance control I, see section **Controls**, to test substance and/or assay medium for compounds with LDH activity.
Strong color reaction in effector cells controls.	Poor conditions of the effector cells due to inappropriate isolation or culture conditions.	Improve cell culture conditions.
		Separate viable effector cells from dead cells by density gradient centrifugation.

4. Additional Information on this Product

4.1. Test Principle

The cell-free culture supernatant is collected and incubated with the reaction mixture from the kit. LDH activity is determined in an enzymatic test:

1. NAD^+ is reduced to $NADH/H^+$ by the LDH-catalyzed conversion of lactate to pyruvate.

2. The catalyst (diaphorase) transfers H/H^+ from $NADH/H^+$ to the tetrazolium salt INT which is reduced to formazan (Fig. 7).

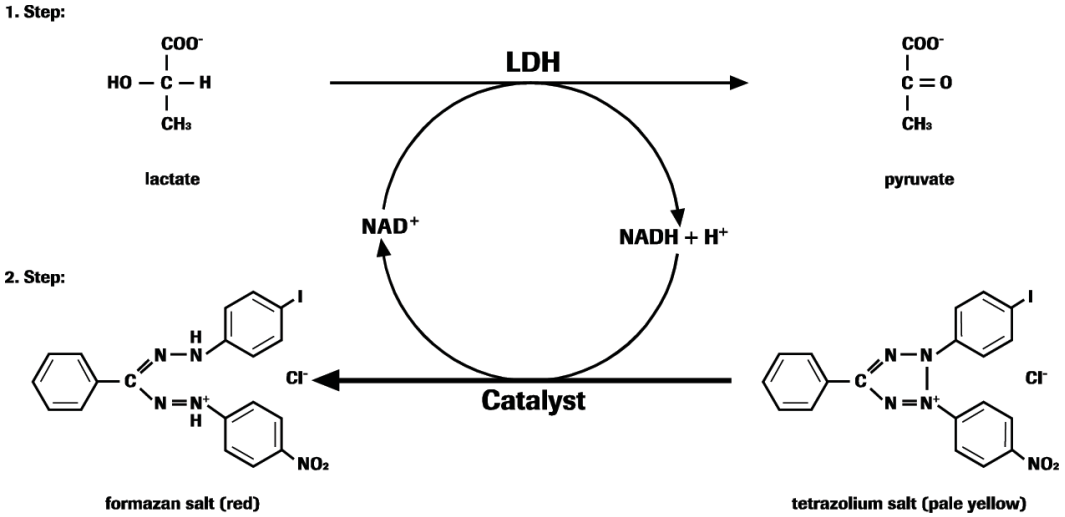

Fig. 7: In the first step, released lactate dehydrogenase (LDH) reduces NAD^+ to $NADH^+$ H^+ by oxidation of lactate to pyruvate. In the second enzymatic reaction 2 H are transferred from $NADH^+$ H^+ to the yellow tetrazolium salt INT (2-[4-iodophe-nyl]-3-[4-nitrophenyl]-5-phenyltetrazolium chloride) by a catalyst.An increase in the amount of dead or plasma membrane-damaged cells results in an increase of the LDH activity in the culture supernatant. This increase in the amount of enzyme activity in the supernatant directly correlates to the amount of formazan formed during a limited time period. Therefore, the amount of color formed in the assay is proportional to the number of lysed cells. The formazan dye formed is water soluble and has a broad absorption maximum at approximately 500 nm, whereas the tetrazolium salt INT shows no significant absorption at these wavelengths (Fig. 8).

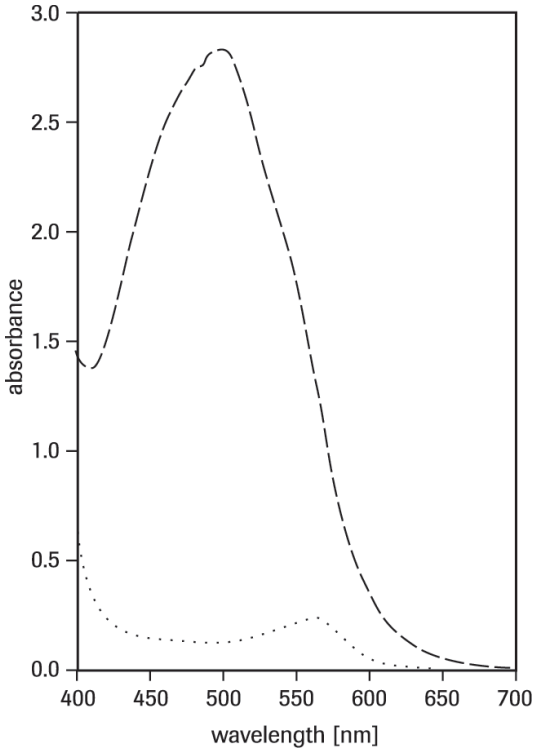

Fig. 8: Absorbance spectra of the working solution of the Cytotoxicity Detection Kit (LDH). The reaction mixture of the Cytotoxicity Detection Kit (LDH) was added to RPMI 1640 with 1% BSA and the absorbance spectra was measured in the absence (.....) and presence (– – –) of LDH.

How this product works

Cell death is classically evaluated by quantifying plasma membrane damage. The need for sensitive, quantitative, reliable, and automated methods for precisely determining cell death led to the development of several standard assays for the quantification of cellular viability.
Lactate dehydrogenase (LDH) is a stable cytoplasmic enzyme present in all cells. It is rapidly released into the cell culture supernatant when the plasma membrane is damaged. With the use of the Cytotoxicity Detection Kit (LDH), activity can easily be measured in culture supernatants by a single measurement at one time point. A spectrophotometric microplate reader (ELISA reader) may be used to simultaneously measure multiple wells and thereby makes easy processing of a large number of samples possible. The test is safe as no radioactive isotopes are used.

5. Supplementary Information

5.1. Conventions

To make information consistent and easier to read, the following text conventions and symbols are used in this document to highlight important information:

Text convention and symbols	
Information Note: Additional information about the current topic or procedure.	
Important Note: Information critical to the success of the current procedure or use of the product.	
① ② ③ etc.	Stages in a process that usually occur in the order listed.
❶ ❷ ❸ etc.	Steps in a procedure that must be performed in the order listed.
* (Asterisk)	The Asterisk denotes a product available from Roche Diagnostics.

5.2. Changes to previous version

Layout changes.
Editorial changes.
New information added related to the REACH Annex XIV.
Update to include new safety Information to ensure handling according controlled conditions.

5.3. Trademarks

All product names and trademarks are the property of their respective owners.

5.4. License Disclaimer

For patent license limitations for individual products please refer to:
List of biochemical reagent products.

5.5. Regulatory Disclaimer

For life science research only. Not for use in diagnostic procedures.

5.6. Safety Data Sheet

Please follow the instructions in the Safety Data Sheet (SDS).

5.7. Contact and Support

To ask questions, solve problems, suggest enhancements or report new applications, please visit our **Online Technical Support Site**.

To call, write, fax, or email us, visit **sigma-aldrich.com**, and select your home country. Country-specific contact information will be displayed.

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